Developing and Testing A Predictive Model for the Pedestal Height and Width

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The pressure at the top of the edge transport barrier (or "pedestal height") in tokamaks strongly impacts global confinement and fusion performance. Accurately predicting the pedestal height in ITER and demonstration power plants is an essential element of prediction, and a powerful tool for optimization, of fusion performance.

We develop and test a model for the H-mode pedestal height and width based upon two fundamental and calculable constraints: 1) onset of non-local peeling-ballooning modes at low to intermediate mode number, 2) onset of nearly local kinetic ballooning modes at high mode number. Calculation of these two constraints allows a unique, predictive determination of both pedestal height and width. The present version of the model is first principles, in that no parameters are fit to observations, and includes important non-ideal effects.

The model is extensively tested against high resolution pedestal measurements on several tokamak experiments, including dedicated experiments on Alcator C-Mod at a wide range of toroidal magnetic field (3.5, 5.4 and 8 Tesla), and on DIII-D, taking advantage of a new high resolution Thomson scattering system. The predicted pedestal height has been found to agree with observations to an accuracy of ~20% [eg 1-3].

We continue to explore extensions to both the KBM and peeling-ballooning calculations in the model. More sophisticated models of diamagnetic stabilization are explored via 2-fluid calculations. Direct gyrokinetic studies of the edge barrier plasmas using the GYRO and TGLF codes are used to explore the KBM and related micro-instabilities.

Prior tests of the EPED model have focused on H-mode discharges with Edge Localized Modes (ELMs), but it is also of interest to study discharges where ELMs are suppressed, for example by 3D magnetic perturbations (often called Resonant Magnetic Perturbations, RMP). We find that a combination of the EPED model with realistic plasma response calculations yields a plausible model for RMP ELM suppression, including an approximate prediction of the required range of q_{95} for ELM suppression.

[1] P.B. Snyder *et al.*, Phys. Plasmas **16** 056118 (2009).
[2] P.B. Snyder *et al.*, Nucl. Fusion **49** 085035 (2009)
[3] P.B. Snyder, R.J. Groebner, J.W. Hughes et al. "A First Principles Predictive Model of the Pedestal Height and Width: Development, Testing and ITER Optimization with the EPED Model," submitted to Nucl Fusion Jan 2011.